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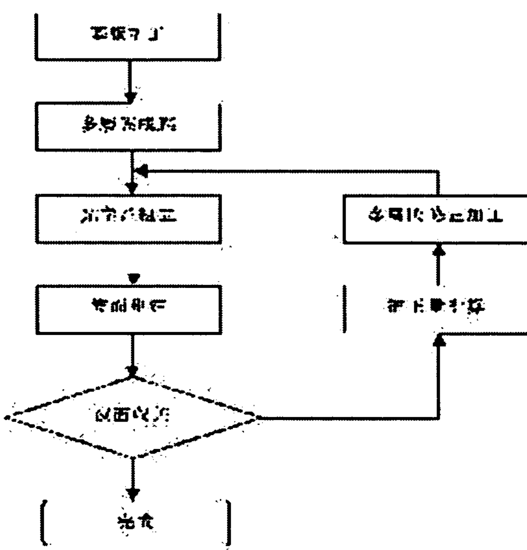
(54) OPTICAL SYSTEM MANUFACTURING METHOD AND EUV ALIGNER



(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method of practically manufacturing an optical system by applying a technology of removing a surface layer of a multilayer film, to correct the surface shape of a multilayer film mirror.

SOLUTION: The method comprises a board processing step of processing mirror boards at specified shape accuracy and a specified surface roughness, a multilayer film forming step of forming multilayer films on the mirror boards, an optical system assembling step of mounting the multilayer film mirrors in a tube to assemble an optical system, a wave front measuring step of measuring the wavefront aberration of the mirrors at an operating wavelength, a correction calculating step of calculating the correction of each mirror surface shape from the measured wave front, if the measured wave front aberration lies outside a specified value, and a step of removing a specified thickness portion of the multilayer film to correct the mirror shape, followed by the assembling of the optical system and the measurement of the wave front aberration, and repeats a cycle of the correction calculating step, multilayer film correcting process step, optical system assembling step and wave front aberration measuring step, until the wave front aberration satisfies the specified value.

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CLAIMS

[Claim(s)]

[Claim 1] The first process which processes into a predetermined configuration precision two or more mirror substrates which constitute optical system, The second process which forms the multilayers which reflect the light of predetermined wavelength in each mirror substrate, Thus, the third process which fixes each manufactured multilayers mirror to a lens-barrel, and assembles optical system, The fourth process which measures the wave aberration of the optical system concerned on the operating wavelength of the optical system concerned, Until wave aberration becomes below a predetermined value including the fifth process which computes the amount of amendments of optical system from the measured wave aberration, and the sixth process which amends the configuration which removes the multilayers front face of each multilayers mirror alternatively, and is equivalent to the amount of configuration amendments The manufacture approach of the optical system characterized by repeating successively the fifth process, sixth process, third process, and fourth process.

[Claim 2] The manufacture approach of the optical system according to claim 1 characterized by inserting the process which processes a hole, notching, etc. between said first process and second process.

[Claim 3] The manufacture approach of the optical system according to claim 1 or 2 characterized by making [more] the number of laminatings of multilayers in said second process than the sum with the maximum of a number of layers required in order to obtain a predetermined reflection factor at the time of use of optical system, and the number of layers removed by configuration amendment.

[Claim 4] It is the manufacture approach of optical system given in any 1 term among claim 1 to claims 3 characterized by measuring wave aberration on two or more wavelength in said fourth process.

[Claim 5] It is the manufacture approach of optical system given in any 1 term among claim 1 to claims 4 which make a performance index the sum of squares in the pupil surface into which the difference of the optical-path-length change when amending optical system and the amount of gaps from the non-aberration wave front of the measured wave front was divided in said fifth process, and are characterized by computing the amount of amendments by optimizing so that this performance index may become min.

[Claim 6] It is the manufacture approach of optical system given in any 1 term among claim 1 to claims 5 characterized by computing the parameter about the mutual location of a mirror, and the configuration of a mirror as an amount of amendments of optical system.

[Claim 7] It is the manufacture approach of optical system given in any 1 term among claim 1 to claims 5 characterized by computing only the parameter about the configuration of a mirror as an amount of amendments.

[Claim 8] It is the manufacture approach of optical system given in any 1 term among claim 1 to claims 7 characterized by expressing the parameter about a mirror configuration by system of orthogonal functionses, such as the Zernike polynomials.

[Claim 9] It is the manufacture approach of optical system given in any 1 term among claim 1 to claims 8 characterized by adding a limit so that only the discrete numeric value which makes a unit the field configuration change considerable amount when removing a part for a round term of multilayers as an amount of amendments about a mirror configuration may be adopted , in case the amount of amendments is optimized .

[Claim 10] It is the manufacture approach of optical system given in any 1 term among claim 1 to claims 9 characterized by observing the field internal division cloth of the amount of processings with the image by the light or infrared light with a wavelength of 400nm or more in said sixth process.

[Claim 11] The reflecting mirror characterized by preparing a coordinate reference mark outside the service

area of a reflector.

[Claim 12] Soft-X-ray optical system characterized by being constituted using the optical system manufactured by the approach given in any 1 term, or a reflecting mirror according to claim 11 among claim 1 to claims 10.

[Claim 13] The EUV aligner characterized by having soft-X-ray optical system according to claim 12.

[Claim 14] The EUV aligner characterized by being constituted using the optical system manufactured by the approach given in any 1 term, or a reflecting mirror according to claim 11 among claim 1 to claims 10.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the EUV aligner equipped with the manufacture approach of the optical system used for the soft-X-ray projection aligner used for manufacture of a semiconductor device etc., other soft-X-ray optical instruments, etc., the soft-X-ray optical system manufactured by this manufacture approach, and soft-X-ray optical system.

[0002]

[Description of the Prior Art] In order to raise the resolution of the optical system restricted by the diffraction limitation of light with progress of detailed-izing of a semiconductor integrated circuit component in recent years, instead of the conventional ultraviolet rays, the projection lithography technique which used soft X ray with a wavelength [with wavelength shorter than this] of about 11-14nm is developed. (For example, D.Tichenor, et al., SPIE 2437 (1995) 292 reference) Those contents are the same although this technique is also recently called EUV (Extreme Ultra Violet: extreme ultraviolet rays) lithography. (It is hereafter called EUV lithography) . EUV lithography is expected by the conventional optical lithography (wavelength of about 190nm or more) as a future lithography technique of having unrealizable resolution 70nm or less.

[0003] Since the refractive index of the matter is very close to 1 in this wavelength region, the conventional optical element using refraction or reflection cannot be used. Therefore, the oblique incidence mirror using the total reflection by a refractive index being more slightly [than 1] small, the multilayers mirror which doubles a phase, is made to carry out the a large number superposition of the feeble reflected light in an interface, and obtains a reflection factor high as a whole are used. In the wavelength region near 13.4nm, if the Mo/Si multilayers which carried out the laminating of a molybdenum (Mo) layer and the silicon (Si) layer by turns are used, 67.5% of reflection factor can be obtained by direct incidence, and if the Mo/Be multilayers which carried out the laminating of Mo layer and the beryllium (Be) layer by turns are used, 70.2% of reflection factor can be obtained by direct incidence in the wavelength region near the wavelength of 11.3nm. (For example, C.Montcalm, Proc.SPIE, Vol.3331 (1998) P.42 reference.)

[0004] EUV lithography equipment is mainly constituted by the soft-X-ray light source, an illumination-light study system, a mask stage, image formation optical system, the wafer stage, etc. The laser plasma light source, the discharge plasma light source, synchrotron orbital radiation, etc. are used for the soft-X-ray light source. An illumination-light study system is constituted by the oblique incidence mirror which reflects in a reflector the soft X ray which carried out incidence from across, the multilayers mirror in which a reflector is formed of multilayers, the filter which makes only the soft X ray of predetermined wavelength penetrate, and is illuminated with the soft X ray of the wavelength of a request of on a photo mask. In addition, since the matter transparent in the wavelength region of soft X ray does not exist, not the mask of the conventional transparency mold but the mask of a reflective mold is used for a photo mask. Image formation of the circuit pattern formed on the photo mask is carried out on the wafer with which the photoresist was applied, and it is imprinted by the projection image formation optical system which consisted of two or more multilayers mirrors etc. at a photoresist. In addition, in order for soft X ray to be absorbed by atmospheric air and to decrease it, the whole of the optical path is maintained by the predetermined degree of vacuum (for example, 1x10 to 5 or less Torrs).

[0005] Projection image formation optical system is constituted by two or more multilayers mirrors. Since the reflection factor of a multilayers mirror is not 100%, in order to suppress loss of the quantity of light, as for the number of sheets of a mirror, lessening as much as possible is desirable. Until now, the optical system

(for example, T.Jewell and K.Thompson, USP 5,315,629, T.Jewell, USP 5,063,586 reference) which consists of four multilayers mirrors, the optical system (for example, D.Williamson, JP,9-211332,A, USP 5,815,310 reference) which consists of six multilayers mirrors are reported.
[0006] Unlike the dioptric system to which the flux of light advances to an one direction, by catoptric system, the flux of light will go in optical system. For this reason, it is difficult for there to be a limit of avoiding the eclipse of the flux of light by the mirror, and to enlarge numerical aperture (NA). Although NA is made only by about 0.15 in four-sheet optical system, the design of optical system with still larger NA is attained in six-sheet optical system.
[0007] In such optical system, the number of sheets of a mirror is usually even number so that a mask stage and a wafer stage can arrange on both sides of projection image formation optical system. Since such projection image formation optical system must amend the aberration of optical system with the limited number of pages, it is the ring field optical system by which the aspheric surface configuration was applied to each mirror, and aberration was amended only near the predetermined image quantity. In order to imprint the whole pattern on a photo mask on a wafer, it exposes making a mask stage and a wafer stage scan at a different rate by the scale factor of optical system.
[0008] The above projection image formation optical system of an aligner is the so-called optical system of a diffraction limitation, and unless it makes wave aberration small enough, it cannot obtain the engine performance as a design. As a standard of the allowed value of the wave aberration in the optical system of a diffraction limitation, there are criteria less than of 1/14 of operating wavelength with the mean square value (RMS) by Marechal. (M.Born and E.Wolf, Principles of Optics, 4th edition, Pergamon Press 1970, p.469 reference) This is conditions for Strehl reinforcement (ratio of the maximum of the point reinforcement between optical system and non-aberration optical system with aberration) to become 80% or more. In order to fill a severe demand of a line breadth controllability etc., the actual projection image formation optical system of an aligner is manufactured so that it may become aberration still lower than this.
[0009] In the EUV lithography technique in which researches and developments are done briskly now, as for exposure wavelength, the wavelength 13nm or near 11nm is mainly used. The configuration error (FE) permitted by each mirror is given by the degree type to the wave aberration (WFE) of optical system.
FE=WFE/(2*n1/2) [RMS] -- (1) n is the number of the mirrors which constitute optical system here, and divide by further 2 because a twice as many error as a configuration error rides on wave aberration, since both incident light and the reflected light are influenced of a configuration error in catoptric system, respectively. After all, in the optical system of a diffraction limitation, the configuration error (FE) permitted by each mirror is given by the degree type as a function of the number of sheets n of wavelength lambda and a mirror.
FE=lambda/(28*n1/2) [RMS] -- In the case of the optical system by which the value of FE was constituted from wavelength of 13nm by four mirrors according to the (2) and (2) type, it is 0.23nm. In the case of the optical system which was set to [RMS] and consisted of six mirrors, it is 0.19nm. It is set to [RMS]. However, it is very difficult to manufacture the mirror of such a highly precise aspheric surface configuration, and EUV lithography has become the first easily unutilizable cause. The process tolerance of the aspheric surface attained by current is 0.4-0.5nm. It is extent of [RMS] (C.Gwyn, Extreme Ultraviolet Lithography White Paper, EUV LLC, 1998, p17 reference), and in order to realize EUV lithography, the large improvement in the processing technique of the aspheric surface and a measurement technique is needed.
[0010] The epoch-making technique which can amend Factice's nm configuration error substantially was reported by by shaving off the front face of a multilayers mirror every further recently (M.Yamamoto, 7 th International Conference on Synchrotron Radiation Instrumentation, Berlin Germany, August 21-25, 2000, POS 2-189). The principle is explained using drawing 2 .
[0011] it is shown in drawing 2 (a) -- as -- A and B -- the case where a pair is further removed as shown in drawing 2 (b) is considered from the front face of the multilayers which carried out the laminating of two kinds of matter by turns by the fixed cycle length d. The optical path length OP of a multilayers 1-layer pair of thickness d to the beam of light which advances perpendicularly to a multilayers front face by drawing 2 (a) is OP=nA*dA+nB*dB. -- It is given by (3). dA and dB express the thickness of each class and is dA+dB=d here. nA and nB -- Matter A and B -- it is each refractive index. Optical-path-length OP' of the part of thickness d which removed the one layer pair of multilayers on the front face of the maximum by drawing 2

(b) is OP'=n*d. -- It is given by (4). n expresses a vacuous refractive index and is 1. By removing the maximum upper layer of multilayers, the optical distance to which the beam of light which passes through that progresses will change. This is optically [as having corrected the field configuration by the change substantially .] equivalent. The change (namely, change of a field configuration) delta of the optical path length is delta=OP'-OP. -- It is given by (5).

[0012] In the wavelength region of soft X ray, since the refractive index of the matter is close to 1, delta becomes a small amount and amendment of a precise field configuration is attained by this approach. As an example, the case where Mo/Si multilayers are used on the wavelength of 13.4nm is shown. In order to use it by direct incidence, they may be d= 6.8nm, dMo=2.3nm, and dSi=4.5nm. The refractive indexes in this wavelength are nMo=0.92 and nSi=0.998. If change of the optical path length is calculated using these numeric values, they are OP=6.6nm and OP'=6.8nm, It is set to delta= 0.2nm. That is, processing which removes a layer with a thickness of 6.8nm can amend the field configuration of 0.2nm (reflector configuration).

[0013] In addition, since the refractive index of Si layer is close to 1 in the case of Mo/Si multilayers, change of the optical path length is not based mainly on the existence of Mo layer, and it hardly depends for it on the existence of Si layer. Therefore, in case the layer of multilayers is removed, there is no need of controlling the thickness of Si layer correctly. In this example, processing should just stop the thickness of Si layer in the middle of those with 4.5nm, and this layer. That is, field configuration amendment of 0.2nm unit can be performed by processing precision of several nm.

[0014] In addition, if the reflection factor of multilayers increases with the number of laminatings and a fixed number of layers is exceeded, it will be saturated, and it becomes fixed. If the laminating of sufficient number of layers to saturate a reflection factor beforehand is carried out, even if it removes some multilayers from a front face, change of a reflection factor will not be produced.

[0015]

[Problem(s) to be Solved by the Invention] Although this approach was very effective, the approach of applying this approach to manufacture of actual optical system was not necessarily clear.

[0016] Let it be a technical problem to make this invention in view of such a situation, to apply the technique which removes the surface layer of multilayers and amends the field configuration of a multilayers mirror, and to offer the EUV aligner which has the method of actually manufacturing optical system and a suitable reflecting mirror to use it for this approach, the soft-X-ray optical system that has the optical system manufactured by this approach, and such soft-X-ray optical system.

[0017]

[Means for Solving the Problem] The first process which processes into a predetermined configuration precision two or more mirror substrates with which the 1st means for solving said technical problem constitutes optical system, The second process which forms the multilayers which reflect the light of predetermined wavelength in each mirror substrate, Thus, the third process which fixes each manufactured multilayers mirror to a lens-barrel, and assembles optical system, The fourth process which measures the wave aberration of the optical system concerned on the operating wavelength of the optical system concerned, Until wave aberration becomes below a predetermined value including the fifth process which computes the amount of amendments of optical system from the measured wave aberration, and the sixth process which amends the configuration which removes the multilayers front face of each multilayers mirror alternatively, and is equivalent to the amount of configuration amendments It is the manufacture approach (claim 1) of the optical system characterized by repeating successively the fifth process, sixth process, third process, and fourth process.

[0018] In this means, he is the erector of the optical system as having been carried out conventionally with the first process to the third same process. In this means, after doing in this way and completing the assembly of optical system, in the fourth process, the wave aberration of the optical system concerned is measured on the operating wavelength of optical system. This can be performed using a well-known interferometer.

[0019] And in the fifth process, the amount of amendments of optical system is computed from the measured wave aberration. Here, in the amount of amendments of optical system, the amount of amendments of the shape of surface type of each multilayers mirror is contained at least. In addition, "the shape of surface type

of a mirror" is a configuration of the reflector at the time of considering not the physical shape of actual surface type but a multilayers mirror to be the mirror which has a single reflector.

[0020] Next, in the sixth process, alternative removal of multilayers is performed so that the amount of amendments of the shape of surface type of the multilayers mirror obtained at the fifth process may be obtained using the surface type-like correction approach of the multilayers mirror by the multilayers removal explained using drawing 2 . That is, multilayers are removed as the thickness of the multilayers removed according to the surface part of a multilayers mirror is changed. It can be called for by the aforementioned (3) formula - (5) type it is necessary what number of layers of multilayers to remove corresponding to the amount of amendments of the shape of surface type of the multilayers mirror obtained at the fifth process.

[0021] In addition, in case it moves from the fifth process to the sixth process, it cannot be overemphasized that the assembled optical system must be decomposed. Moreover, in the fourth process performed first, when it is below the predetermined value whose wave aberration is an allowed value, it cannot be overemphasized that the fifth process and the sixth process are also unnecessary.

[0022] The fourth process is again returned and carried out to the third process continuously after the sixth process termination. And when the measured wave aberration becomes below the predetermined value that is an allowed value, all processes are ended there. When wave aberration has not become below a predetermined value, the third process and the fourth process are again performed through the fifth process and the sixth process. This actuation is repeated until the wave aberration measured at the fourth process becomes below a predetermined value.

[0023] Thereby, using the configuration correction technique of the multilayers mirror by removal of multilayers, configuration amendment of a multilayers mirror can be performed and wave aberration can be certainly made less than into an allowed value.

[0024] The 2nd means for solving said technical problem is said 1st means, and is characterized by inserting the process which processes a hole, notching, etc. between said first process and second process (claim 2).

[0025] It is necessary to decide the appearance of each mirror that the reflected beam of light is not kicked by the mirror in catoptric system like EUV optical system. Therefore, a hole and notching are prepared in a mirror in many cases. if substrate appearance processing of a hole, notching, etc. tends to be performed first and it is going to perform substrate processing which sends mirror configuration precision afterwards -- the periphery of a hole or notching -- "edge -- the phenomenon who" will arise and process tolerance will be degraded. "edge -- who" is the phenomenon in which a desired configuration precision is not acquired by a polish rate consisting of other parts early near [the periphery section, a periphery of a hole, etc.]. if substrate processing which sends mirror configuration precision previously is performed and substrate appearance processing of a hole, notching, etc. is performed afterwards -- "edge -- although who" is not produced, deformation will arise by disconnection of the internal stress by substrate appearance processing shortly.

[0026] In this means, the process which processes a hole, notching, etc. between the first process which processes a mirror substrate into a predetermined configuration precision, and the second process which forms the multilayers which reflect the light of predetermined wavelength in each mirror substrate is inserted. therefore, "edge -- who" does not arise Moreover, since deformation of the mirror produced according to the process which processes a hole, notching, etc. is compensated by adjustment of the mirror configuration by removal of multilayers, it can be made into the configuration aiming at a mirror configuration.

[0027] The 3rd means for solving said technical problem is said the 1st means or 2nd means, and is characterized by making [more] the number of laminatings of multilayers than the sum with the maximum of a number of layers required in order to obtain a predetermined reflection factor at the time of use of optical system, and the number of layers removed by configuration amendment in said second process (claim 3).

[0028] In this means, since it is made [more] than the sum with the maximum of the number of layers which needs the number of layers of the multilayers formed in order to obtain a predetermined reflection factor at the time of use of optical system, and the number of layers removed by configuration amendment, also after performing configuration amendment, the amendment film of a number of layers required in order to obtain a predetermined reflection factor at the time of use of optical system can remain, and, therefore, a predetermined reflection factor can be obtained. A number of layers required in order to obtain a

predetermined reflection factor at the time of use of optical system can be found by the well-known count technique. The maximum of the number of layers removed by configuration amendment can be calculated by experience.
[0029] The 4th means for solving said technical problem is either of said 1st means to the 3rd means, and is characterized by measuring wave aberration on two or more wavelength in said fourth process (claim 4).
[0030] The wavelength region where such optical system is used has a certain amount of breadth, although usual is narrow. Therefore, evaluation of wave aberration is attained to the wavelength of the area within operating wavelength by measuring wave aberration on two or more wavelength of the area within operating wavelength. Therefore, using the wave aberration to two or more wavelength as a performance index, the amount of amendments of optical system can be computed and the configuration amendment in consideration of all the wavelength of the area within operating wavelength is attained so that an example may be raised as a gestalt of operation to behind.
[0031] The 5th means for solving said technical problem is either of said 1st means to the 4th means, and is set at said fifth process. The sum of squares in the pupil surface into which the difference of the optical-path-length change when amending optical system and the amount of gaps from the non-aberration wave front of the measured wave front was divided is made into a performance index, and it is characterized by computing the amount of amendments by optimizing so that this performance index may become min (claim 5).
[0032] In this means, the pupil which a beam of light passes is divided into plurality, and the amount of gaps with the non-aberration wave front of the measured wave front is calculated about the beam of light which passes through each divided field and carries out image formation to one point of the image surface. On the other hand, it asks for change of the optical path length obtained when [each of these beams of light] optical system is amended about ******** as a function of the parameter which amends optical system. And the amount of gaps with the non-aberration wave front of the measured wave front will be compensated with change of the optical path length obtained when optical system is amended. Since there are two or more optical paths, a parameter is determined using a least square method.
[0033] That is, the difference of change of the optical path length obtained about the beam of light which passes through said divided field in each, and carries out image formation to one point of the image surface when optical system is amended, and the amount of gaps with the non-aberration wave front of the measured wave front is searched for, it asks for the square of this difference about all beams of light, **'s and others sum is taken, and the parameter which amends optical system so that that sum may be made into min is determined.
[0034] Thereby, the amount of amendments of optical system can be calculated in consideration of the beam of light passing through all the locations of a pupil surface.
[0035] The 6th means for solving said technical problem is either of said 1st means to the 5th means, and is characterized by computing the parameter about the mutual location of a mirror, and the configuration of a mirror as an amount of amendments of optical system (claim 6).
[0036] This means is effective when the adjustment parts of optical system are both the interrelation of a mirror, and the configuration of each mirror. That is, since both can be found as an amount of amendments of an optical system, it becomes possible to adjust both to coincidence.
[0037] The 7th means for solving said technical problem is either of said 1st means to the 5th means, and is characterized by computing only the parameter about the configuration of a mirror as an amount of amendments (claim 7).
[0038] This means is effective when the adjustment part of optical system is only the configuration of each mirror.
[0039] The 8th means for solving said technical problem is either of said 1st means to the 7th means, and is characterized by expressing the parameter about a mirror configuration by system of orthogonal functionses, such as the Zernike polynomials, (claim 8).
[0040] Since the order of a polynomial can be chosen according to the precision made into the purpose while it is possible to compute the complicated amount of amendments symmetrical with nonrotation if this technique is taken in, the count which determines a parameter by the shortest time amount according to the purpose can be made to complete in either of said 1st means to the 7th means, although it is the well-known

approach to express the parameter about a mirror configuration by system of orthogonal functionses, such as the Zernike polynomials.

[0041] the 9th means for solve said technical problem be either of said 1st means to the 8th means , and in case it optimize the amount of amendments , it be characterize by add a limit so that only the discrete numeric value which make a unit the field configuration change considerable amount when remove a part for a round term of multilayers as an amount of amendments about a mirror configuration may be adopt (claim 9).

[0042] Correction of the mirror configuration by multilayers removal as shown in Fig. 2 is made by removing multilayers per round term (pair unit of the layer which is a pair). Therefore, as an amount of amendments which can be operated, the field configuration change considerable amount when removing a part for a round term of multilayers serves as the minimum unit.

[0043] In this means, since the limit is added so that only the discrete numeric value which makes a unit the field configuration change considerable amount when removing a part for a round term of multilayers as an amount of amendments about a mirror configuration may be adopted in case the amount of amendments is optimized, only the actually applicable amount of amendments can be obtained as a solution.

[0044] The 10th means for solving said technical problem is either of said 1st means to the 9th means, and is characterized by observing the field internal division cloth of the amount of processings with the image by the light or infrared light with a wavelength of 400nm or more in said sixth process (claim 10).

[0045] As mentioned above, multilayers according [multilayers] to the combination of Mo and Si are used in many cases. In the light or an infrared light field with a wavelength of 400nm or more, as for the reflection factor of Mo and Si, the difference becomes large. Therefore, if the light of this wavelength region is irradiated and the processed screen is observed, the striped pattern according to the amount of processings will be observed according to the difference of the reflection factor of Mo and Si in a processing cross section. Therefore, since the amount of processings can be measured by observing this striped pattern, it is processible, checking whether the target processing is performed.

[0046] The 11th means for solving said technical problem is a reflecting mirror (claim 11) characterized by preparing a coordinate reference mark outside the service area of a reflector.

[0047] In this means, since it is processible by making a coordinate reference mark into a reference point, exact processing is possible. Moreover, since a coordinate reference mark is prepared outside the service area of a reflector, it does not affect the optical property of a reflecting mirror.

[0048] The 12th means for solving said technical problem is the optical system manufactured with either of said 1st means to the 10th means, or soft-X-ray optical system (claim 12) characterized by being constituted using the reflecting mirror which is said 11th means.

[0049] In this means, since the wave aberration of optical system used can be adjusted so that it may become in tolerance certainly, it can consider as soft-X-ray optical system with a high precision.

[0050] The 13th means for solving said technical problem is an EUV aligner (claim 13) characterized by having said 12th means.

[0051] The 14th means for solving said technical problem is an EUV aligner (claim 14) characterized by consisting of said 1st means using the optical system manufactured with either of the 10th means, or the reflecting mirror which is said 11th means.

[0052] In these EUV aligners, since the wave aberration of optical system used can be adjusted so that it may become in tolerance certainly, it can consider as an EUV aligner with a high precision.

[0053]

[Embodiment of the Invention] Hereafter, the example of the gestalt of operation of this invention is explained using drawing. Drawing 1 is drawing showing the manufacture process of the optical system which is the gestalt of operation of this invention.

[0054] First, a mirror substrate is processed into a predetermined configuration precision and surface roughness as the first process (substrate processing). In the case of the projection optics of an EUV exposure machine, the configuration of each mirror is not the spherical surface but the aspheric surface, and the number of sheets of the mirror which constitutes optical system has cases, such as four sheets, six sheets, and eight etc. sheets.

[0055] Next, as the second process, multilayers are formed to these mirror substrates (multilayers

membrane formation). Generally near the wavelength of 13nm, Mo/Si multilayers are used. The cycle length of multilayers is decided by the incident angle of operating wavelength and a beam of light. Since the incident angle of a beam of light changes with locations also in the field of one mirror, it forms membranes by controlling distribution of thickness to a precision so that a beam of light can be reflected efficiently in every location.

[0056] Next, as the third process, these multilayers mirrors are attached in a lens-barrel, and optical system is assembled (optical-system assembly). The wave aberration of optical system originates not only in the configuration error of each mirror but in the rigging error of optical system. It roughly divides into the approach of assembling optical system, and there are two kinds of approaches among them. One is the approach of assembling only in mechanical assembly precision, and another is the approach of assembling, while adjusting by establishing an adjustment device.

[0057] In order to adjust the latter, the wave front to the light may be measured using the interferometer which used the lights, such as helium-Ne laser. Although the wave front of EUV wavelength and the wave front measured by the light are not strictly the same, since the difference is comparatively small, it can use for rigging.

[0058] Next, as the fourth process, the wave aberration of the assembled optical system is measured on the wavelength to be used (wave-front measurement). In the case of EUV exposure machine projection optics, a wave front is measured with the EUV light near 13nm. Although the Fizeau interferometer is generally used for wave-front measurement of an ultraviolet-rays field from the light, the another measurement approach is needed in the wavelength region of EUV which cannot use a lens. PDI which performs comparison measurement with the diffracted-wave side by the pinhole (Point Diffraction Interferometer) For example, K.Goldberg, et al., Proc.SPIE, and Vol.3997 (2000) p.867 reference, The shearing interferometer carry out [horizontal **] and pile up by carrying out a wave front (for example) P.Naulleau and et al., Abstract of the 44th By using technique, such as International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication (2000), and P.94 reference The wave front of the optical system in EUV wavelength can be measured. Measurement of wave aberration is measured in respect of plurality so that the situation of not only one in the exposure field but the whole exposure field may be known.

[0059] EUV optical system has the bandwidth of the magnitude of extent which cannot be disregarded compared with operating wavelength. For example, the bandwidth of the projection optics which consisted of six Mo/Si multilayers mirrors for the wavelength of 13.4nm is 0.35nm. Although catoptric system does not have chromatic aberration theoretically, since the phase change by multilayers reflection changes with wavelength, wave aberration changes with wavelength slightly strictly. That is, the chromatic aberration resulting from multilayers occurs.

[0060] In order to optimize in consideration of this effect, it is good for there to be nothing only on one wavelength and to perform measurement of wave aberration on two or more wavelength. For example, as shown in drawing 6 , wave aberration is measured on the wavelength lambda1 and lambda3 of the perimeter other than the projection system permeability peak location wavelength lambda 2. The wave aberration measured changes slightly with wavelength. From such wave aberration, the average is calculated carrying out weighting according to the permeability of the optical system in each measurement wavelength, and let this be the wave aberration of optical system. By completing such a procedure, the value of the wave aberration which expressed the actual property of optical system more correctly can be acquired. If the value of the measured wave aberration is contained in predetermined specification value within the limits, optical system is completion now. Generally, since it does not yet go into specification value within the limits in this phase, the following processes are carried out.

[0061] That is, the amount of amendments of each multilayers mirror side configuration is calculated from the measured wave front as the fifth process (the amount count of amendments). The method of calculating the amount of amendments is as follows.

[0062] First, the measured wave front is suitably divided finely in consideration of precision to calculate, the capacity of a computer, etc. An approach which may divide the whole wave-front surface equally and carries out the fragmentation rate only of the center is sufficient as the method of division. The amount of gaps from a non-aberration wave front of each divided area central part is set to f1-fn. Next, a pupil is divided into the same configuration as the time of dividing a wave front to the design solution of the optical system which

became origin, and the optical path length from a body to the image of the beam of light which passes through each center of a division part is calculated. Each optical path length at this time is set to g1-gn.
[0063] changing spacing of a mirror, an inclination, and eccentricity **** -- radius of curvature and the aspheric surface -- counting or Zernike -- g1-gn change to g'1 - g'n by changing the configuration of the mirror expressed by counting etc. Here, a performance index phi is set up as follows.
[0064]
[Equation 1]

$$\Phi = \sum_{i=1}^{n} w_i (g'_i - g_i - f_i + k)^2 \qquad \ldots(6)$$

[0065] Here, w1-wn are weighting at the time of the count to each optical path, and although 1 is altogether sufficient, the beam of light near a pupil core is thought as important, and they select it suitably according to a demand to make light of a surrounding beam of light. Moreover, k is the real number chosen so that phi may always become min, and is one of the unknowns in (6) types.
[0066] (6) In a formula, if this k is disregarded, when only the value corresponding to the amount fi of gaps from the non-aberration wave front of a wave front changes the optical path length from gi to g'i, the inside of the parenthesis of left part will serve as zero. If such a thing can be performed to all i, wave aberration can be set to 0 to all beams of light. However, since such a thing cannot be performed in fact, g'i and k are determined that phi of (6) types will become min with a least square method.
[0067] That is, if it asks for **** of a parameter with which this performance index phi serves as min by solving an optimization problem by making the mutual location (spacing, an inclination, eccentricity) of a mirror, and the configurations (radius of curvature, the aspheric surface counting, Zernike counting etc.) of a mirror into a parameter by count and asks for the difference of a design value and the optimized parameter, it will serve as the amount of amendments. Thus, generally not only the amount of amendments of the parameter about the configuration of a mirror but the parameter about the mutual location of a mirror is contained in the calculated amount of amendments.
[0068] What is necessary is just to adjust according to the amount of amendments of the parameter about the mutual location of the mirror obtained from the above-mentioned count, in readjusting the location of a mirror according to a certain adjustment device, in case a mirror is again included in a lens-barrel and optical system is assembled, after reworking multilayers. What is necessary is just to perform optimization which makes the parameter about the mutual location of a mirror a fixed value, and only the parameter about the configuration of a mirror is changed and makes a performance index min in the case of the lens-barrel device which does not readjust a mirror location.
[0069] About the parameter about a mirror configuration, although only a component symmetrical with rotation can be amended only with radius of curvature or the number of non-spherometers, it is possible by developing to system of orthogonal functionses, such as a Zernike polynomial, and expressing a field configuration to compute the complicated amount of amendments symmetrical with nonrotation.
[0070] In order to simplify the above explanation, the case where it optimized only about one in the field of optical system was described. In fact, wave aberration is measured in two or more image point locations in the field, and it optimizes so that wave aberration may become small in all locations. What is necessary is just to specifically set up a performance index phi as follows by the sum of the divided pupil surface, and the sum of two or more image points chosen in the field.
[0071]
[Equation 2]

$$\Phi = \sum_{i=1}^{n} \sum_{j=1}^{m} w_i (g'_{ij} - g_{ij} - f_{ij} + k_j)^2 \qquad \ldots(7)$$

[0072] gij by the optical path length of the beam of light which passes along i partition of the pupil divided in the formula among the beams of light which carry out image formation to the image point j (7) Calculated value and g'ij By the new optical path length who changed by changing spacing of a mirror, an inclination, and eccentricity or changing radius of curvature, the number of non-spherometers, and the configuration of a

mirror, an unknown and fij In the amount of gaps from the non-aberration wave front of the beam of light which passes along i partition of the pupil divided among the beams of light which carry out image formation to the image point j, an actual measurement, weighting at the time of count of as opposed to each optical path in wij, and kj are the real numbers as which phi is chosen so that it may become min, and are always one of the unknowns in (7) types.

[0073] The approach currently generally used for the optimization algorithm at the time of a lens design can be used for the count technique which asks for the parameter which minimizes the performance index phi in (6) and (7) types. For example, what is necessary is just to use the DLS method (Damped Least Squares, attenuation least square method) etc. Or the technique of the optimization count latest [, such as Simulated Annealing and Genetic Algorithm (genetic algorithm),] may be used.

[0074] General optimization algorithm is searched for the group of the parameter which makes a performance index min, changing a parameter continuously. However, since multilayers are further removed the pair every in case multilayers are removed and a reflector configuration is amended, the amount of amendments which can actually be performed is not continuous, and is discrete. There is a possibility that an error may accumulate and wave aberration cannot be reduced even for sufficient precision even if it performs the usual optimization count and amends a field configuration using the approximate value. Then, in case optimization count of a parameter is performed, about the parameter about a mirror configuration, it is desirable to give limit that only a discrete value can be taken beforehand and to optimize a parameter.

[0075] It is the requisite that the count technique of the amount of amendments in which it explained above has the small wave aberration of the optical system before amending to extent of which approximation that change of wave aberration is linearity consists to change of a parameter. What is necessary is just to decide the specification value of the process tolerance of a required mirror substrate, and the assembly precision of a lens-barrel beforehand based on it, since the range where this premise is realized can be estimated by count.

[0076] Next, as the sixth process, when only predetermined thickness removes multilayers partially, a mirror configuration is amended. As mentioned above, since the amount which actually removes multilayers is larger than the effectual amount of amendments of a reflector configuration single or more figures, precise field configuration amendment is possible.

[0077] as the approach of removing multilayers partially -- the small tool correction grinding method, an ion beam machining method, and CVM (Chemical Vapor Machining) -- law etc. can be used, the one approach is invented by this invention persons, and patent application is carried out as an application for patent No. 321031 [2000 to].

[0078] When it is going to process the complicated configuration symmetrical with nonrotation expressed by the Zernike polynomial etc., it is necessary to decide correctly the system of coordinates which serve as [which location of a mirror side is processed, and] criteria. Therefore, the mark used as the criteria of a coordinate is prepared in the mirror side outside the service area of each mirror. In case this reference mark performs rigging of optical system, it can also be used as criteria for reproducing the eccentricity of each mirror, an azimuth, an inclination, etc.

[0079] In order only for predetermined thickness to remove multilayers partially, it is necessary to carry out by processing advancing correctly towards a predetermined configuration, or repeating a check in the middle of processing. Although the depth of the part processed with the optical level difference plan may be measured, the simplest approach is mechanical in measuring a field configuration with an interferometer, or a method of using the periodic structure of multilayers itself as a contour line. If the front face of multilayers is shaved off partially, a high line, such as consisting of a difference of a color among two kinds of matter which constitutes multilayers, can be seen. Feedback can be applied to partial removal processing by viewing or picturizing this and performing an image processing.

[0080] drawing 7 -- the spectrum of Mo and Si -- a surface reflection factor is shown. Since the reflection factors of the part to which Mo appeared in the front face, and the part in which Si appeared differ when it observes using the light or infrared light with a wavelength of 400nm or more so that clearly from this drawing, the aforementioned contour line is observable. Since the difference of a reflection factor becomes large so that wavelength becomes long, in case an image pick-up and an image processing are performed, it is desirable to use infrared light with a wavelength of 1000nm - about 1500nm.

[0081] After ending the sixth process, assembly of return optical system is again performed to the third

process, and wave aberration measurement which is the fourth process is performed. Optical system will be completion if the wave aberration measured here is in specification value within the limits. When not fulfilling a specification value, the fifth amount count process of amendments, the sixth multilayers rework process, and the third optical-system erector carry out the cycle of the fourth wave aberration measurement process repeatedly again until wave aberration fulfills a specification value.

[0082] It is necessary to decide the appearance of each mirror that the reflected beam of light is not kicked by the mirror in catoptric system like EUV optical system. Therefore, a hole and notching are prepared in a mirror in many cases. if substrate appearance processing of a hole, notching, etc. tends to be performed first and it is going to perform substrate processing which sends mirror configuration precision afterwards -- the periphery of a hole or notching -- "edge -- the phenomenon who" will arise and process tolerance will be degraded. "edge -- who" is the phenomenon in which a desired configuration precision is not acquired by a polish rate consisting of other parts early near [the periphery section, a periphery of a hole, etc.]. if substrate processing which sends mirror configuration precision previously is performed and substrate appearance processing of a hole, notching, etc. is performed afterwards -- "edge -- although who" is not produced, deformation will arise by disconnection of the internal stress by substrate appearance processing shortly.

[0083] That for solving such a trouble should just manufacture optical system at a process as shown in drawing 3 R> 3. Although the process shown in drawing 3 resembles well the process shown in drawing 1 , it differs in that the substrate appearance processing process is inserted between the substrate processing process and the multilayers membrane formation process. Punching of a substrate and processing of notching formation are performed here. Although deformation will arise and the configuration precision of a mirror will deteriorate by substrate appearance processing, a multilayers membrane formation process and an optical-system erector perform a wave-front measurement process more nearly continuously. The component resulting from the configuration error produced according to deformation by substrate appearance processing is contained in the measured wave aberration. The process of drawing 1 and the same process are advanced after this. Since the deformation produced by substrate appearance processing by passing the amount count process of amendments and a multilayers rework process will be amended automatically, it does not have a bad influence on the last engine performance of optical system.

[0084]

[Example] Hereafter, the example which applied this invention to the projection optics of an EUV aligner is explained.

(Example 1) As shown in drawing 4 , projection optics consists of four aspheric surface mirrors, and numerical aperture (NA) is 0.1, a scale factor is 1/4, and it has the ring field-like exposure field. Sequential reflection is carried out by mirrors M1, M2, M3, and M4, and image formation of the flux of light emitted from the object surface is carried out to the image surface. The appearance of each mirror (M1-M4) which constitutes this optical system in drawing 5 is shown. The opening 11 for letting the flux of light pass is formed in M1, M3, and M4. The notching 12 for preventing KERARE of the flux of light is formed in M2. The slash section shows the service area 13 of each mirror. The mark 14 used as coordinate criteria is formed in the outside of a service area.

[0085] First, each aspheric surface mirror was manufactured with the conventional polish processing technique. The configuration precision of each mirror is about 0.5nm. It was [RMS]. Each mirror was beforehand sculptured into the coordinate reference mark 14 in the phase of roughing.

[0086] Then, substrate appearance processing which forms punching of M1, M3, and M4 and notching of M2 was performed. When the configuration of each mirror was measured after performing these processings, process tolerance is 0.7-0.9nm. It had deteriorated in [RMS]. Disconnection of internal stress takes place and deforms this by having removed a part of mirror. In addition, although configuration measurement was performed after substrate appearance processing in this example, there is usually no need of performing configuration measurement in this phase.

[0087] Next, the Mo/Si multilayers optimized to the operating wavelength of 13.4nm were formed in the reflector of each mirror. The number of laminatings of multilayers which the cycle length of multilayers has in the range of 6.8-7.3nm, and is optimized according to the incident angle of the beam of light in a mirror **** location was made into 70 layers. These multilayers formed membranes, controlling thickness distribution by ion beam sputtering.

[0088] Next, these multilayers mirrors were fixed in the lens-barrel, and optical system was assembled. Only mechanical precision performed assembly of optical system and adjustment etc. was not performed. When assembling optical system, it used on the basis of the coordinate reference mark 14 so that the azimuth of each mirror might become in the always same direction. In addition, this lens-barrel is designed in the mirror by removable structure with sufficient repeatability.
[0089] Next, the wave aberration in the wavelength of 13.4nm of optical system was measured. The SHARINGU interferometer which used the laser plasma light source was used for measurement. Measurement of wave aberration was performed by 15 in the radii-like field. The value of the measured wave aberration is 1.9nm. [RMS] to 2.5nm It was the range of [RMS].
[0090] Next, the amount of amendments of each mirror was calculated from the measured wave aberration and an optical design solution by the approach explained with "the gestalt of implementation of invention." It optimized by making the Zernike polynomial showing the configuration of each mirror of the 36th term into a parameter. Since it did not have the adjustment device of a lens-barrel in this example, the parameter showing the mutual location of a mirror was not used for the parameter of optimization count.
[0091] Next, from the lens-barrel, each mirror was removed and the configuration was reworked according to the computed amount of amendments. Small tool polish equipment was used for processing. The image by the light on the front face of a mirror was acquired with the CCD camera, the Mo section and the Si section which appeared in the front face by processing were observed, and it acted as the monitor of the advance situation of processing. At this time, the coordinate reference mark 14 was used as coordinate criteria within a field.
[0092] Next, each mirror was again included in the lens-barrel, optical system was assembled, and wave aberration with a wavelength of 13.4nm was measured. Then, wave-front measurement of rework of each mirror and optical system was able to be repeated several times, and, finally wave aberration of optical system was able to be set to 0.5 or less nmRMSs all the points in the field.
[0093] Thus, it included in the EUV aligner as shows the manufactured projection optics to drawing 8 R> 8, and the exposure test was performed. IR1-IR4 are the reflecting mirrors of an illumination-light study system among drawing, and PR1-PR4 are the reflecting mirrors of projection optics. W is a wafer and M is a mask.
[0094] It is condensed by Target S and the laser beam irradiated from the laser light source generates soft X ray from Target S according to a plasma phenomenon. It is reflected by reflecting mirrors C and D and incidence of this soft X ray is carried out to an illumination-light study system as parallel soft X ray. And sequential reflection is carried out with the reflecting mirrors IR1-IR4 of an illumination-light study system, and the lighting field of Mask M is illuminated. With the reflecting mirrors PR1-PR4 of projection optics, sequential reflection is carried out and the soft X ray reflected by the pattern formed in Mask M carries out image formation of the image of a pattern to the Wth page of a wafer. In this EUV aligner, even the detailed pattern of 50 nmL&S (Rhine and tooth space) was resolvable.
[0095] (Example 2) The example which applied this invention to the projection optics of an EUV aligner is explained. Projection optics consists of six aspheric surface mirrors, and numerical aperture (NA) is 0.25, a scale factor is 1/4, and it has the ring field-like exposure field.
[0096] First, each aspheric surface mirror was manufactured with the conventional polish processing technique. The configuration precision of each mirror is about 0.5nm. It was [RMS]. Then, substrate appearance processing which forms punching of M1, M3, and M4 and notching of M2 was performed.
[0097] Next, the Mo/Si multilayers optimized by the operating wavelength of 13.4nm were formed in the reflector of each mirror. The number of laminatings of multilayers which the cycle length of multilayers has in the range of 6.8-7.5nm, and is optimized according to the incident angle of the beam of light in a mirror **** location was made into 70 layers. These multilayers formed membranes, controlling thickness distribution by ion beam sputtering. At the time of membrane formation, on the substrate, the mask was carried out and multilayers were formed only in the service area. The suitable opening pattern for a mask is prepared at this time, and the mark used as the coordinate criteria made in multilayers was prepared in the outside of a service area.
[0098] Next, these multilayers mirrors were fixed in the lens-barrel, and optical system was assembled. The adjustment device is prepared in this lens-barrel, and mirror spacing, the eccentricity of a mirror, an

inclination, etc. can be tuned finely. The device in which it can read correctly which moved each amount of adjustments by the micrometer head is established. Rigging of optical system was performed using the Fizeau interferometer which makes helium-Ne laser the light source, looking at the wave front by the light. When assembling optical system, it used on the basis of the coordinate reference mark so that the azimuth of each mirror might become in the always same direction. A coordinate reference mark may be used for measurement of the eccentricity of not only an azimuth but a mirror, or an inclination. In addition, this lens-barrel is designed in the mirror by removable structure with sufficient repeatability.

[0099] Next, the wave aberration in the wavelength of 13.4nm of optical system was measured. The PDI (Point Diffraction Interferometry) interferometer which used the undulater light source of synchrotron orbital radiation was used for measurement. Measurement of wave aberration was performed by 15 in the radii-like field. In each point of measurement, wave-front measurement was performed on three wavelength, 13.2nm, 13.4nm, and 13.6nm, and weighting was carried out with the permeability of the optical system in each wavelength, and the average was taken and it considered as the wave aberration in the location. The value of the measured wave aberration is 1.7nm. [RMS] to 2.4nm It was the range of [RMS].

[0100] Next, the amount of amendments of each mirror was calculated from the measured wave aberration and an optical design solution by the approach explained with "the gestalt of implementation of invention." It optimized by making the Zernike polynomial showing the configuration of each mirror of the 81st term into a parameter. Mirror spacing showing the mutual location of a mirror other than the multiplier of the Zernike polynomial expressing the configuration of each mirror, eccentricity, and an inclination were also used for the parameter of optimization count as a parameter.

[0101] Next, from the lens-barrel, each mirror was removed and the configuration was reworked according to the computed amount of amendments. Small tool polish equipment was used for processing. The image by the light on the front face of a mirror was acquired with the CCD camera, the Mo section and the Si section which appeared in the front face by processing were observed, and it acted as the monitor of the advance situation of processing. At this time, the coordinate reference mark was used as coordinate criteria within a field.

[0102] Next, each mirror was again included in the lens-barrel, optical system was assembled, and wave aberration with a wavelength of 13.4nm was measured. Then, wave-front measurement of rework of each mirror and optical system is repeated several times, and, finally it is 0.4nm at all the points in the field about the wave aberration of optical system. It was able to carry out to below [RMS].

[0103] Thus, when the manufactured projection optics was included in the EUV aligner and the exposure test was performed, even the detailed pattern of 30 nmL&S was resolvable.

[0104]

[Effect of the Invention] Since it becomes possible to apply the approach of only a predetermined amount removing the front face of multilayers and amending a reflected wave side configuration effective in manufacture of EUV optical system according to this invention as explained above, the wave aberration of optical system can be reduced and ******** can be improved. Moreover, since the precision required of the first aspheric surface processing is sharply eased as compared with the manufacture approach of optical system of not using the wave-front amendment by the conventional multilayers, compaction of the period which manufacture of optical system takes, and reduction of a manufacturing cost are attained.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the production process of the optical system which is the gestalt of operation of this invention.

[Drawing 2] It is drawing explaining the principle of the reflected wave side phase correction by surface removal of multilayers.

[Drawing 3] It is drawing showing the production process of the optical system which is the gestalt of other operations of this invention.

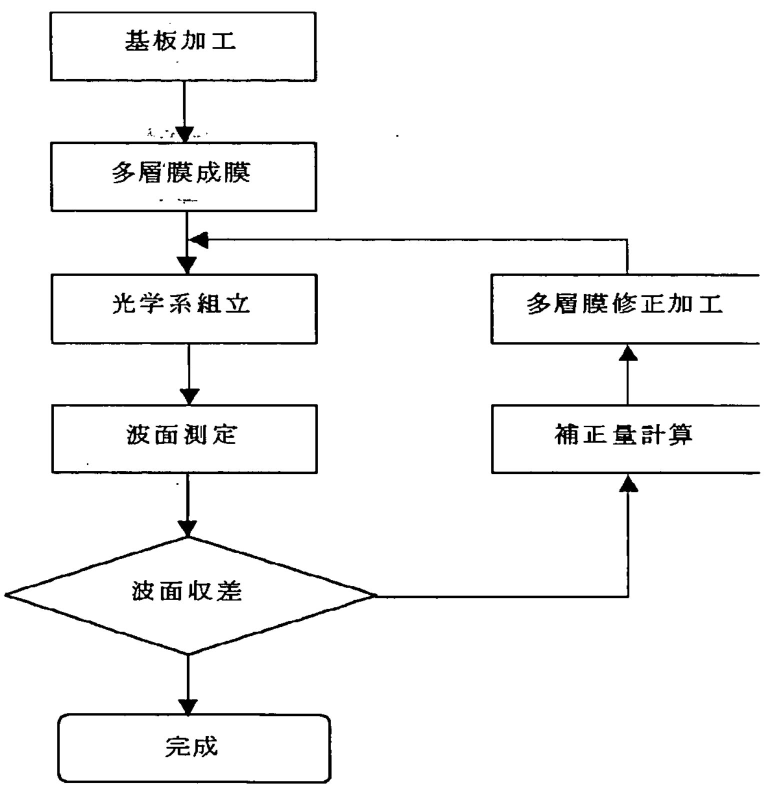
[Drawing 4] It is drawing showing the configuration of the four-sheet aspheric surface projection optics which is the first example of this invention.

[Drawing 5] It is drawing showing the configuration of each mirror which constitutes the four-sheet aspheric

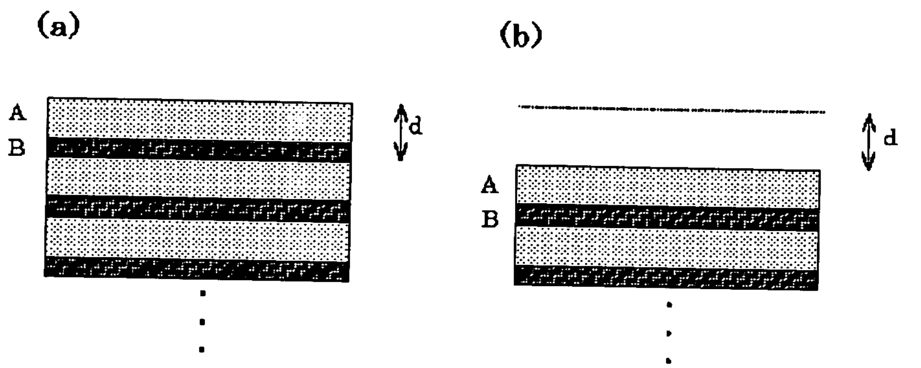
surface projection optics which is the first example.
[Drawing 6] It is drawing explaining how to measure wave aberration on two or more wavelength.
[Drawing 7] the spectrum of Mo and Si -- it is drawing showing a surface reflection factor.
[Drawing 8] It is drawing showing the configuration of suitable soft-X-ray optical system to apply this invention and an EUV aligner.
[Description of Notations]
11 -- Opening
12 -- Notching
13 -- Service area
14 -- Coordinate reference mark
M1-M4 -- Mirror (multilayers mirror)
L -- Laser light source
S -- Target
C -- Reflecting mirror
D -- Reflecting mirror
IR1-IR4 -- Reflecting mirror of an illumination-light study system
PR1-PR4 -- Reflecting mirror of projection optics
M -- Mask
W -- Wafer

DRAWINGS

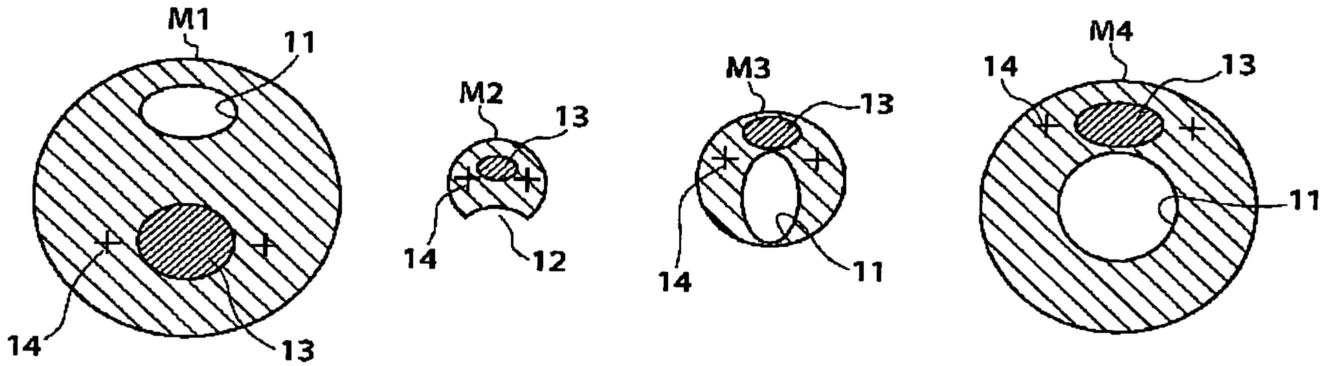
[Drawing 1]



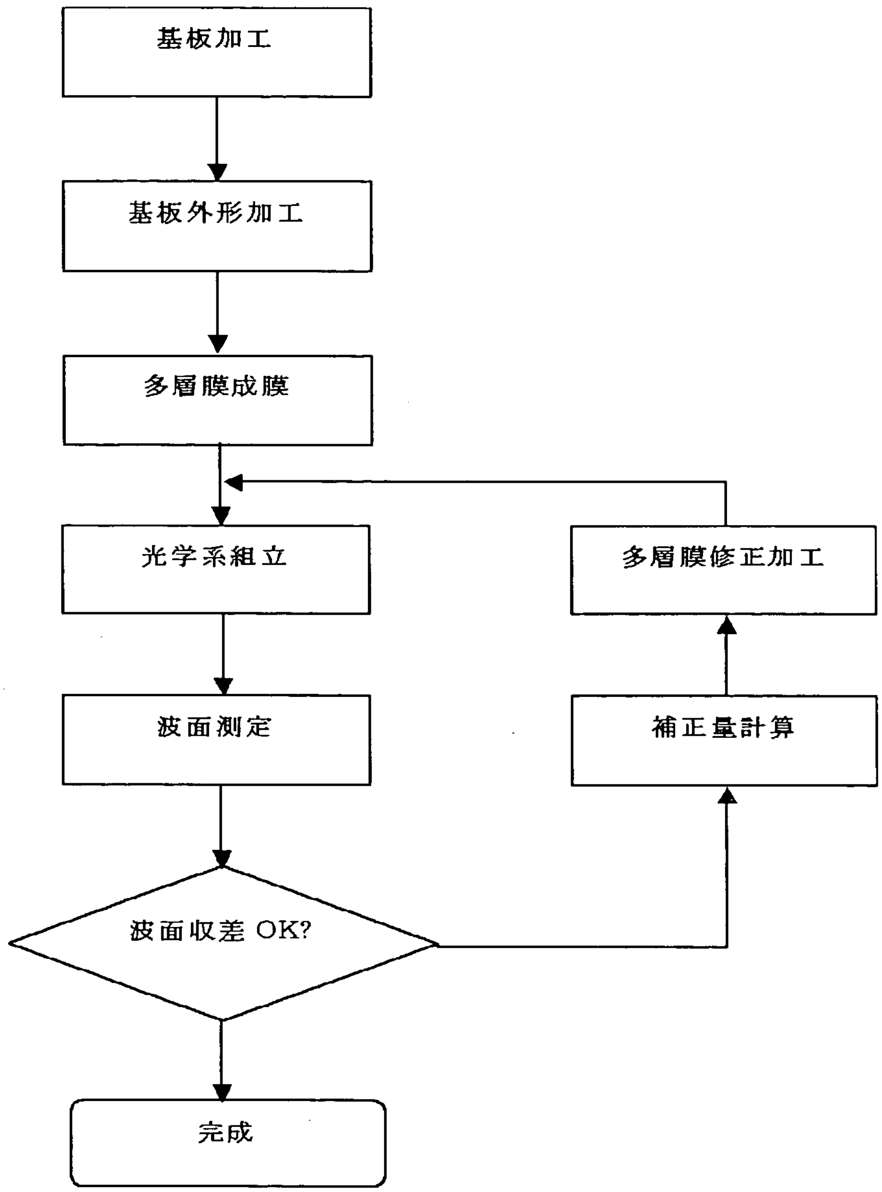
[Drawing 2]



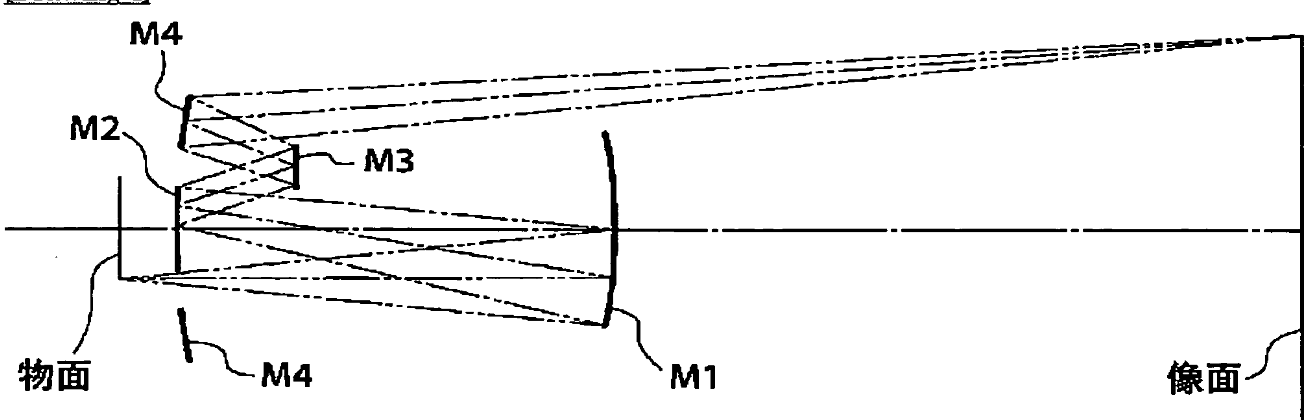
[Drawing 5]



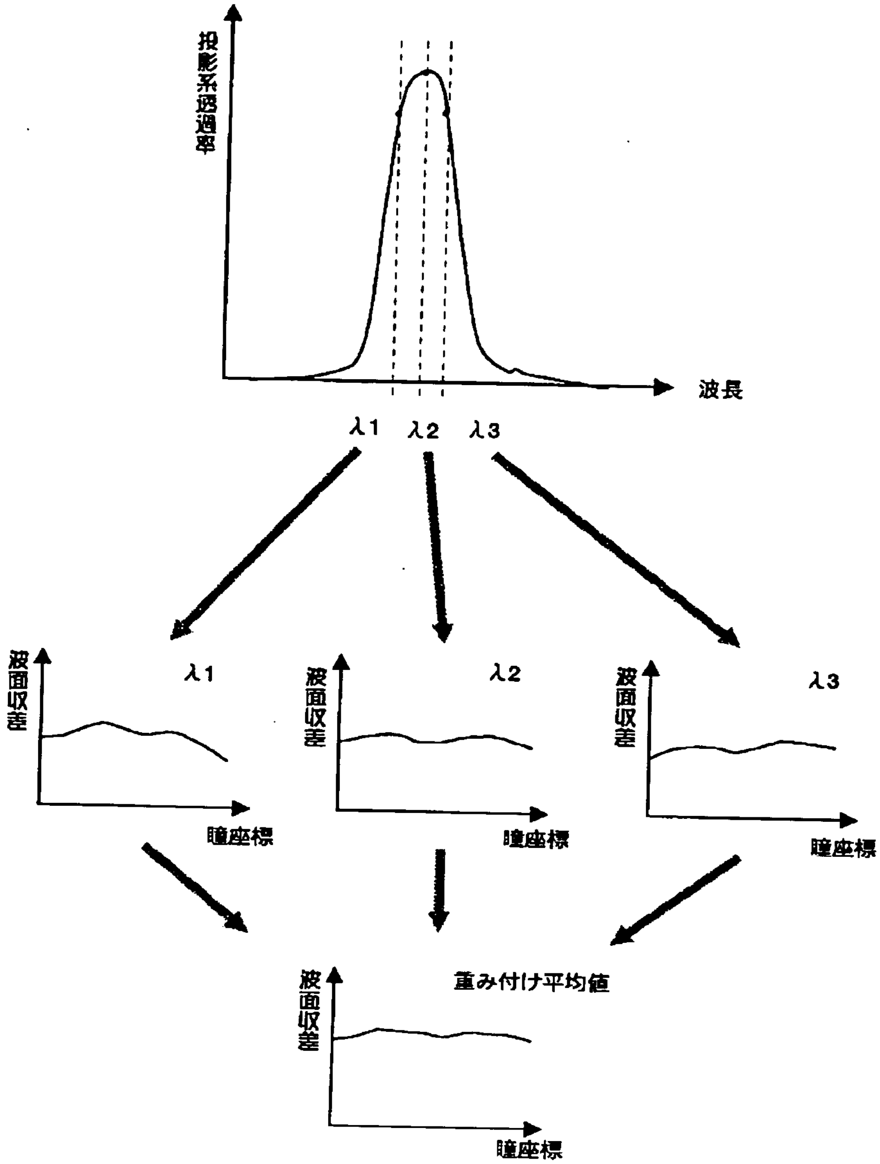
[Drawing 3]



[Drawing 4]



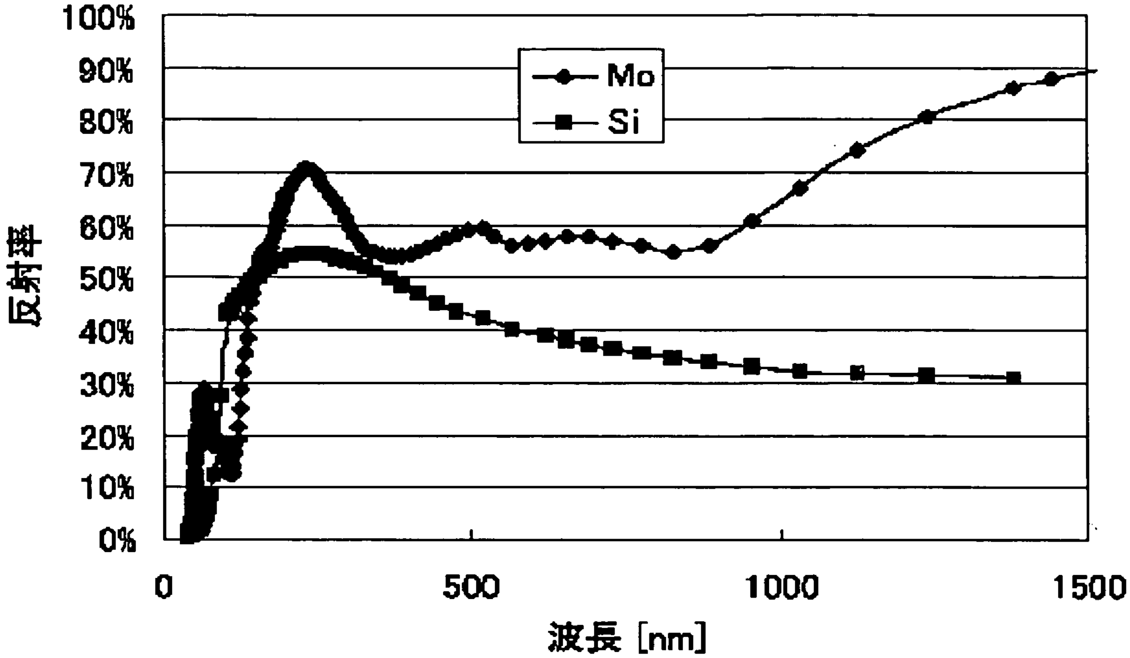
[Drawing 6]



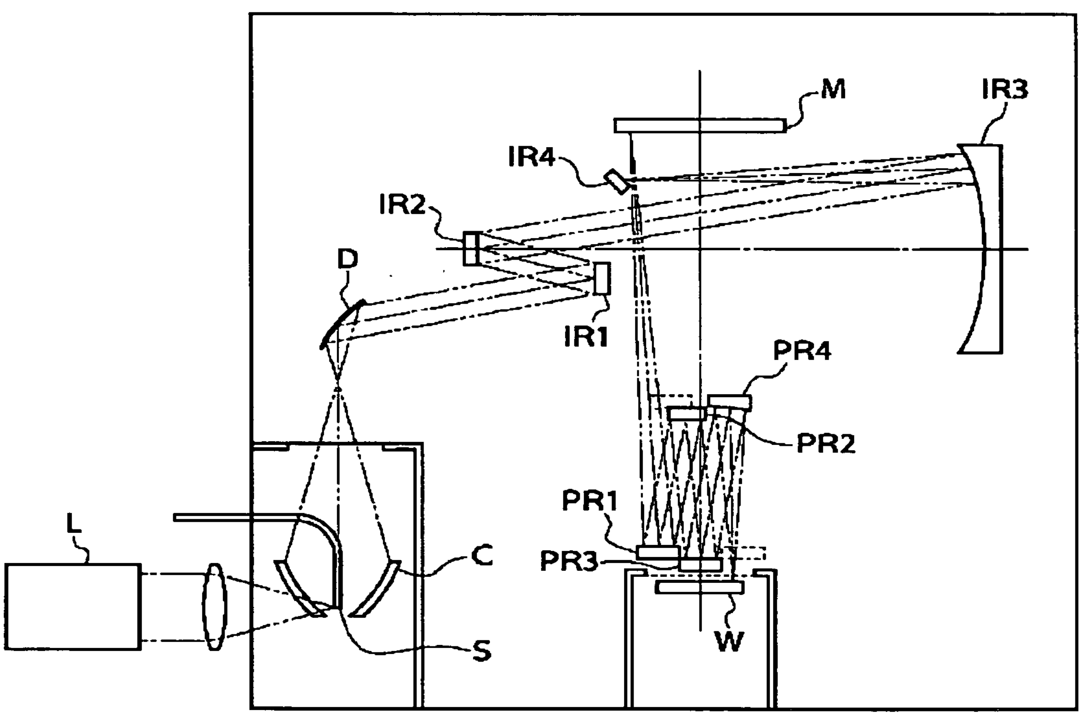
投影系透過率
波長
λ1
λ2
λ3
波面収差
λ1
瞳座標
波面収差
λ2
瞳座標
波面収差
λ3
瞳座標
波面収差
重み付け平均値
瞳座標

[Drawing 7]

MoおよびSiの表面反射率



[Drawing 8]



[Translation done.]